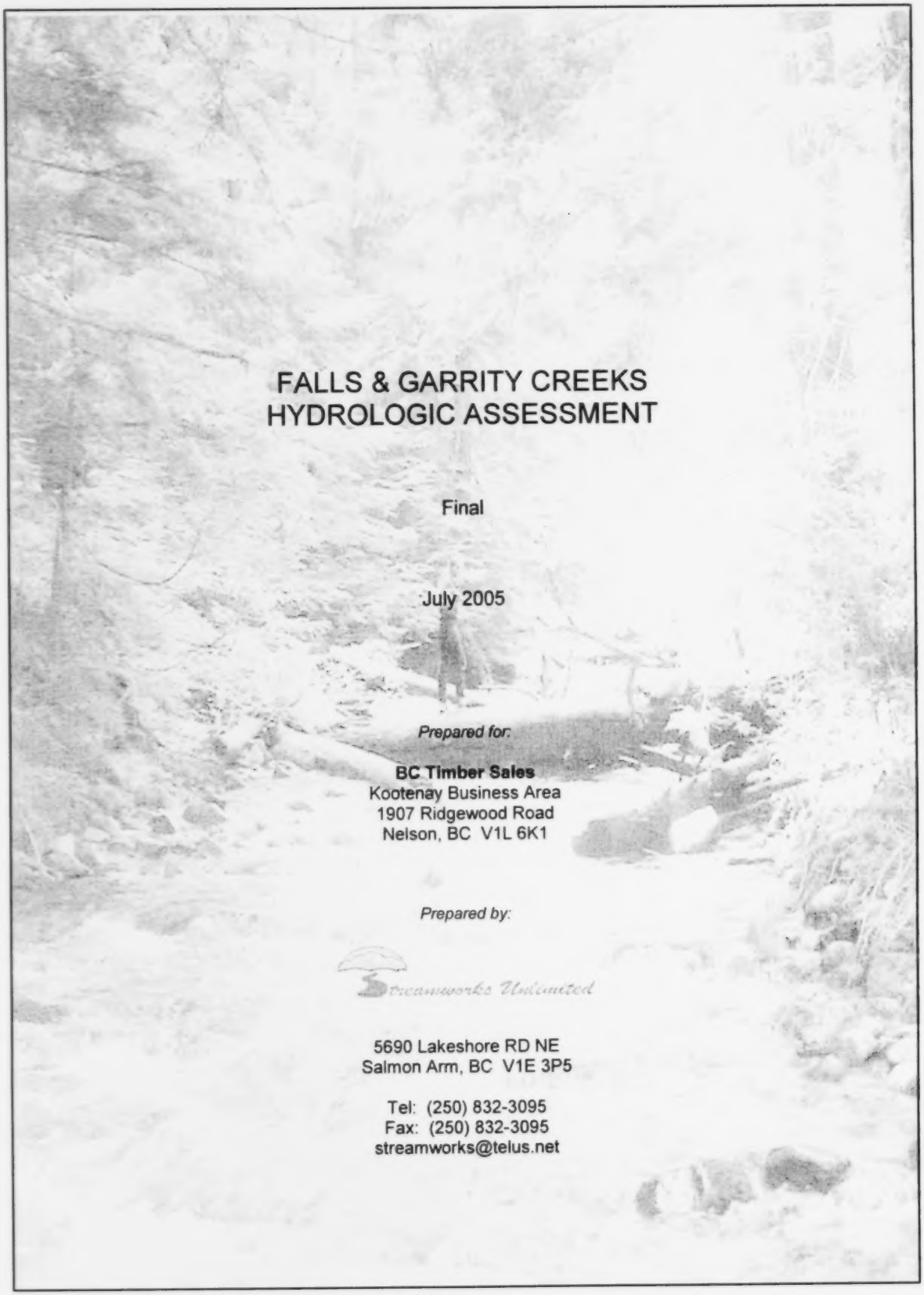

FALLS & GARRITY CREEKS HYDROLOGIC ASSESSMENT

Final

July 2005

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1.0 INTRODUCTION & OBJECTIVES

Streamworks Unlimited (Streamworks) was retained by BC Timber Sales, Kootenay Business Area (BCTS) to conduct hydrological assessments in the Falls and Garrity Creek watersheds, approximately 15km west of Nelson along the Kootenay River. Falls Creek is a community watershed providing water to the Bonnington Improvement District as well as numerous other domestic water licenses. Garrity Creek acts as a source of domestic water to at least ten (licensed) households. Several springs exist in the vicinity of the watersheds that are also diverted for domestic water use. BCTS is currently planning the salvage of pine beetle damaged timber in portions of the watersheds, operations that will include forest harvesting and road construction.

The main purpose of this assessment was to assess potential hydrologic implications or impacts which may result from the proposed harvesting and roads and recommend any mitigative measures considered necessary to protect local water resources. The services to be provided according to the terms of reference for the project are as follows:

- Review the former Falls Creek Interior Watershed Assessment Procedure (IWAP) completed by Carver Consulting in 2000 (Carver, et.al.) and, identify and discuss any constraints to forest development stemming from that assessment.
- Evaluate current and proposed Equivalent Clearcut Area (ECA) levels for both watersheds and provide general hydrologic descriptions and pertinent recommendations with regards to changes in ECA resulting from the proposed development.
- Review any potential connections between proposed forest developments and licensed surface water sources in the area and provide observations and recommendations to mitigate any possible adverse effects.
- Comment on the location and rate of cut as proposed in terms of a hydrological risk assessment.

This report summarizes the findings of these assessments and provides recommendations toward the management of forest and water resources in the watersheds. This document forms part of the deliverables for contract #10005-28/PD2006TKOKO007 administered by BCTS. Falls and Garrity Creek are located within the Kootenay Lake Management Unit.

1.1 Report Use and Limitations of this Study

This report has been prepared in accordance with generally accepted professional practices as applied to the forest industry in British Columbia. Recommendations are the professional opinion of Streamworks Unlimited and Grainger & Associates Consulting Ltd. Findings are based on limited field investigation and inferences from surficial features. No subsurface investigations were undertaken in the development of the reported hypotheses and/or recommendations. Interpretation of field conditions and predicted impacts of future development are judgmental in nature and based on the aforesaid limited investigation, experience and professional opinion. Natural variability in surface and subsurface conditions may create unforeseen situations. Additionally, extreme environmental

conditions could cause unpredictable events and/or outcomes. By using this report, the client acknowledges the limitations of the data and recommendations and assumes full responsibility for its use.

1.2 Previous Assessments and Works in the Study Area

Considerable work has been done to investigate resource use interactions and develop management strategies within the Falls Creek watershed. In 2000, Carver Consulting completed an Interior Watershed Assessment Procedure (IWAP) of Falls Creek for BCTS (Small Business Forest Enterprise Program at the time) and Kalesnikoff Lumber Co. Ltd. (Kalesnikoff). Assessment components included an evaluation of ECA to assess potential changes to flow regimes, a sediment source survey, a reconnaissance channel assessment and a riparian assessment. A risk assessment related to forest development proposed at that time was conducted and specific risk reduction strategies and recommendations toward future harvesting were developed.

Level B terrain mapping and a stream channel assessment had previously been completed by Utzig and Carver in 1999. Original terrain maps (hard copy) from 1999 were provided by BCTS for review in this project. The Utzig and Carver terrain mapping varies somewhat from the digital terrain mapping information provided by BCTS for inclusion with the current project maps. The source of terrain mapping provided on the maps (Figures 1 and 2) is not known and appears to be less detailed than the 1999 mapping. Statements with regards to terrain stability in this report refer to the Utzig and Carver (1999) mapping and may vary slightly from the polygons shown on the attached maps.

The IWAP report also provided a description of rehabilitation opportunities for roads, landslides and other sediment sources within the watershed. Road deactivation prescriptions for the southernmost 2km of the Falls Creek Main FSR, including cost estimates were submitted as an appendix.

In January 2001, D. Putt of Forterra Consultants Ltd. developed a Road Deactivation Plan for the Falls Creek watershed, following up on the priorities identified in the IWAP (all High and Very High hazard road sections). Most of the roads in the watershed were built in the 1950's and 1960's to access timber in the upper watershed. They had fallen into disuse and disrepair, were overgrown and no longer passable in most areas. Detailed deactivation prescriptions were developed for Falls Creek – Main Road (2+080 to 4+600), Falls Creek North Main Road, Falls Creek North Main Spur Roads (Spurs 1 thru 5), Northwest Fork – Main Road and the Northwest Fork Spur Roads (Spurs 1 and 2).

According to Mr. Karl Koerber of Kalesnikoff, all of the prescribed activities in the Forterra report have been carried out since its submission in 2001 (Pers. Comm. Karl Koerber, 14 June 2005). A considerable amount of handwork was required to fulfill the prescriptions as a result of the poor access.

Conversely, no previous assessments exist for the Garrity Creek watershed.

2.0 BACKGROUND

2.1. Study Area

Falls Creek drains approximately 3,380 hectares of mostly forested terrain southward into the Kootenay River, just above the Corra Linn Dam, 16 kilometers west of Nelson, BC. Garrity Creek drains approximately 393 hectares, immediately to the east of the Falls Creek watershed. A 1:20,000 map of the study watersheds, including topography, forest cover, water intake locations and terrain stability information, is provided as Figure 1.

The study area is located in the southern portion of the 'Interior Wet Belt' within the Montane Cordillera ecozone and the Columbia Mountains & Highlands ecoregion. Biogeoclimatic zones found within the watersheds are predominantly Interior Cedar-Hemlock (ICH) with areas of Engelmann Spruce–Sub-Alpine Fir (ESSF) at higher elevations. Patterns of temperature and precipitation are typical for mountainous terrain, with total valley-bottom precipitation in the range of 500 to 800mm/year (Carver et.al. 2000). Annual flow hydrographs for both creeks are snow-dominated with typically more than 90% of the annual runoff occurring in the spring freshet (April-June). Although there are no longer any active stream gauges on Falls Creek, some intermittent gauging records exist dating back to 1921. Garrity Creek was monitored briefly from 1930 to 1933. More details on climate and hydrologic regime (esp. for Falls Creek) are available in the IWAP (Carver et.al. 2000) and Utzig and Carver (1999).

The following description of bedrock and terrain is summarized from Carver (2000). Bedrock in the western portion of Falls creek is dominated by the Vahalla Gneiss Complex (biotie quartz monzonite) whereas in the eastern portion and Garrity Creek there are the Nelson Intrusives (granodiorite with minor diorite). These units are separated by a major extensional fault. The entire study area was covered by ice during Pleistocene glaciation, rounding off the ridges and leaving a network of glaciofluvial deposits, dissected terraces, morainal veneers and blankets. Minor areas of glaciolacustrine deposits, colluvial and fluvial fans also exist in the watersheds. Further details on terrain in Falls Creek can be found in Utzig and Carver (1999).

Forest resources in the Falls Creek watershed are managed by Kalesnikoff (under Forest License A30172) and BCTS. There is privately owned land in the lower ends of both watersheds, the boundary of which is shown on Figure 1. In recent years, mountain pine beetle infestation has caused mortality of Lodgepole Pine stands in the region.

2.2. Licensed Water Use

Locations of surface water diversion points for licensed water use have been indicated on Figure 1 and Figure 2. A listing of water licenses currently on file with Land and Water BC has been provided in Appendix A. Point Codes (PD numbers) shown on the maps can be used to cross reference licensees on the list.

Currently 18 water licenses are registered (6 pending) on Falls Creek, including the Bonnington Improvement District (BID) which has licensed capacity to provide domestic water to 300 households. It was not ascertained how many households are currently

connected to and using the BID system. Garrity Creek has 10 licensed domestic intakes (1 pending). In addition, water licenses exist on numerous groundwater-fed springs in and between the watersheds, mostly within or close to privately owned land.

2.3. Disturbance History

A review of fire and anthropogenic disturbance history in Falls Creek was conducted by Carver (2000) using aerial photography dating back as far as 1939. Fires affected extensive areas of the headwaters in the 1930's and '40's, leaving the riparian zone mainly intact. Extensive road systems were built into the watershed in the 1950's, accompanied by extensive logging in the lower to mid- portions of the headwater sub-basins, and on the ridge extending into Smallwood Creek. Harvesting created significant riparian disturbance and was associated with a number of landslides. In some cases, skid roads were located in, or became stream channels (a practice common at the time). Widening of the mainstem channel, below the main confluence (the lower end of the upper sub-basins) was apparent on the 1958 photography. Forest harvesting continued in the watershed in 1965-68 and 1980-82 (Carver et.al. 2000).

A historical airphoto review has not been conducted for Garrity Creek. Logging in Garrity Creek is more recent, occurring mostly in the 1990's, in conjunction with harvest operations in Smallwood Creek. Access to parts of the west side of Smallwood Creek is through the Garrity Creek watershed.

3.0 METHODOLOGY

3.1. Field Reconnaissance

Inspections of the Falls and Garrity Creek watersheds were made on the 14th and 15th of June, 2005, by Alan Bates, P.Eng. and Bill Grainger, P.Geo. Traverses/inspections included existing roads, mapped stream crossings (on both public and resource roads), key areas of proposed blocks, hillslopes below proposed blocks, water intake sites potentially affected by proposed harvesting, and the mouth of Falls Creek where it discharges into the Kootenay River. An inspection of portions of the Falls Creek mainstem in the vicinity of the community intake was also made. Mr. Mitch Bronaugh (local land owner and water licensee) accompanied the Streamworks inspectors on several of the traverses, providing guiding services, anecdotal observations and adding his extensive, long-term, local knowledge.

Inspection sites and traverse locations throughout the assessments were recorded using Garmin Etrex hand-held Global Positioning System (GPS) receivers. Accuracy of the recorded waypoints generally ranged to ±10 metres. Recorded GPS waypoints have been numbered and plotted on the accompanying maps (Figures 1 and 2) for referral by this report. Some overlap occurred where the same sites were inspected and recorded separately by Mr. Bates and Mr. Grainger.

At the traverse waypoints, items of interest, and typical and/or exceptional conditions were photographed during the assessment using digital cameras. A complete set of assessment photographs and field notes has been provided to BCTS on CD for reference and documentation. Selected photographs have been provided in Appendix C.

The following airphotos made available by BCTS were used in the field and reviewed in the office:

- BCB 97091 – Nos. 052 and 053 **(1997)**
- BCB 00037 – Nos. 138 and 139, BCB 00038 Nos. 48 to 51 and BCB00022 Nos. 138 to 142 **(2000)**

Digital photography used to develop 2004 orthophoto maps for the region did not cover the areas of interest in these watersheds.

3.2. Equivalent Clearcut Area

Equivalent Clearcut Area (ECA) is a measure of the extent of deforestation at a given time in a watershed, including forest openings related to harvesting, private land clearing and/or natural disturbances such as wildfires. Deforestation affects natural processes such as rainfall interception, evapo-transpiration and snow accumulation and melt on a local scale. When deforestation becomes extensive, these local effects may compound to cause broader, watershed scale impacts. Evaluating ECA is useful in assessing the likelihood of cumulative changes to stream flow regimes in a watershed.

Hydrologic recovery is a term used to describe the recovery of the forest following disturbance. Percentage recovery relationships have been developed for BC forests, typically based on tree height, although stand density and crown closure may also be considered where data are available. ECA calculations need to be updated periodically to account for tree growth, recent disturbance and updated silviculture information.

In recent years, outbreaks of mountain pine beetle, spruce bark beetle and fir bark beetle have become epidemic in the province. Tree mortality caused by these infestations has led to significant deforestation in some regions and introduced a new type of forest opening. Although little specific research exists on the hydrologic behavior of beetle-killed stands, it is reasonable to assume that where susceptible species form a major component of the stand, the resulting openings will behave similar to a clearcut. Or, depending on the composition of the stand, they may be considered at least a partial cut, similar to selective harvesting. Based on these assumptions, where beetle kill areas have been identified and documented, they should be included in an assessment of ECA.

The following sections describe the methods used to evaluate ECA in the two study watersheds.

3.2.1 Falls Creek

Typically, ECA is evaluated by reviewing opening information on forest cover mapping and assigning hydrologic recovery based on projected tree heights from silviculture survey information. The previously completed IWAP (Carver et.al. 2000) incorporated a more detailed approach to ECA enumeration, to better account for historical wildfires and harvesting in the watershed. Forest cover polygons were individually assessed on the airphotos and assigned recovery classes according to interpretations of soil characteristics, site series, fire history, stand age, tree height and species composition. Data and calculation tables developed for the previous IWAP were not available for

review or updating at the time of preparation of this report.

Watershed and sub-basin boundaries, and the 'Point of Interest' (POI) were assigned as part of the original IWAP (Anonymous 1999). The POI for the Falls Creek watershed was located at the BID community intake (PD61674), as instructed by BC Water Management Branch (Carver et.al. 2000). The intake shown on the map further downstream (PD28261) was no longer in use.

With the POI at this location, only a small portion (5.2 ha.) of CP 15-71 falls within the contributing area of the Falls Creek watershed. Due to the relatively small amount of proposed salvage harvest occurring within watershed boundary, and the unavailability of the previous detailed work, fully updating the ECA for the Falls Creek watershed was considered unnecessary for this assessment and was not undertaken. Instead, an estimate of hydrologic recovery was made using typical growth rates for the region and projecting from the base information presented in the previously completed watershed report card (Carver et.al. 2000). Recovery estimates and further discussion for Falls Creek ECA can be found in Sections 4.2.1 and 5.3.1. This study also assesses potential impacts to individual springs and intakes within the zone of influence (downslope) of the proposed cutblocks (see Figures 1 and 2).

3.2.2 Garrity Creek

ECA was calculated for the Garrity watershed using information available on forest cover mapping, according to methodologies outlined in the Watershed Assessment Procedure Guidebook (WAPG -Anonymous 1999). The POI was chosen as the downstream-most intake site on the creek (PD28311), and the watershed area above this point was delineated (see Figure 1). The further division of the Garrity Creek watershed into sub-basins was considered unnecessary given the relatively small size of the watershed.

BCTS provided Streamworks with an MS Excel spreadsheet with forest cover information for all the existing openings in the study area. Using this information, current tree heights were projected using Ministry of Forest's Volume Density Yield Projection program for MS Windows (WinVDYP). This program uses age, height, stems per hectare, crown closure, site index and a location indicator to model growth from the reference year and estimate tree heights for the year 2005. This program is approved by the Ministry of Forests for the projection of tree heights and it conforms to Resource Inventory Committee (RIC) standards. Projected tree heights generated by these methods were used to estimate hydrologic recovery according to the revised WAPG (Anonymous 1999).

Research in the Interior of British Columbia has shown that snow typically covers the upper 60% of a watershed when streamflow levels begin to rise in the spring (Anonymous 1999). To assess the effects of harvesting at higher elevations, a hypsometric curve was plotted and the elevation at which 60 percent of the watershed area was above was determined. The contour corresponding to that elevation was then highlighted on the map as an H60 line (see Figures 1 and 2). Typically, forest cover removal in areas above the H60 line is considered to be more significant in affecting major snowmelt peak flows in a watershed. ECA above and below the H60 are then calculated separately to permit a relative weighting of harvesting in the high snowpack zone, at the discretion of the Hydrologist.

Redfish Creek, a research watershed with similar attributes (e.g. biogeoclimatic zone, steepness, aspect, etc.) to the two watersheds in this study is located approximately 35km to the northeast. Numerical modeling calibrated to flow and weather records in the watershed has shown that changes in peak flows are strongly influenced by the elevation distribution of the harvested area (Schnorbus & Alila, 2004). Harvesting below the H60 elevation has been found to have insignificant impact on peak discharge, regardless of harvest extent and event frequency. However, harvesting above the H60 elevation tend to significantly increase annual peak discharge. Changes in runoff synchronization are suspected to be the driving force in peak flow alteration. Based on this research, the weighting of harvest area above the H60 line by a factor of 50% is considered appropriate in this region.

The experimental portion of Redfish Creek is approximately 26 km^2 in size and elevations range from 700 to 2300m. Garrity Creek is approximately 3.9 km^2 in size and elevations range from 660 to 1430m. The subalpine zone occupies only a relatively small portion of the Garrity Creek watershed. Differences in snowpack accumulation and rates of snowmelt between the elevation zones in the smaller watershed will likely be less pronounced. Weighting of harvest area above the H60 line by a factor of 50% (as suggested in the Community Watershed Guidebook [Anonymous 1996b]) has been applied to Garrity Creek as a conservative approach.

Proposed harvest areas were based on the most recent information available from BCTS. In most cases this was the Ministry of Forests, Forest Development Plan (FDP) Amendment #16 (2002-2006) for the study area. For some blocks (notably Block 15-71), recently completed GPS surveys of block layouts were used.

4.0 OBSERVATIONS & RESULTS

The results of the field reconnaissance and the ECA analyses are summarized in the following sections. Existing features, proposed development and GPS waypoints from the field inspections are shown in Figures 1 and 2. Discussions and recommendations with regards to these observations and results are presented in Section 5.0.

4.1. Observations from Field Reconnaissance

4.1.1 Proposed Block 15-71

Block 15-71 occupies a rocky ridge top with predominantly gentle (<30%) gradient slopes with some limited 30 to 40% gradient areas. There is a high Lodgepole Pine (Pl) component and Pl mortality was frequent.

The site is underlain by a sand with trace (<10%) silt colluvial veneer with an increasing high (<50%) coarse fragment content of pebble (2 to 64mm) and cobble (64 to 256mm) sized angular granitic rock fragments that increases with depth. Colluvium overlies fractured bedrock. At ridge tops bedrock exposure is common and colluvial depth varies from 0 to 2m but is commonly less than 1m. Colluvium is thicker on lower slopes within the block area, and there may be isolated pockets of thin glacial deposits. Granitic bedrock on the east side of Falls Creek and in the area of Block 15-71 is very fractured, with a close joint spacing (Photo A). Few block (>256mm) sized particles were observed.

Almost all surface flow infiltrates into colluvium and bedrock with only a few occurrences of surface seepage noted, none of which had any surface connection to downslope surface flows. With one exception, no evidence such as moved surface litter or sediment was encountered to indicate there is overland flow generated on these gentle bedrock slopes. Therefore it is concluded that precipitation on this upslope area infiltrates rapidly into the underlying highly fractured granitic rock.

South (downslope) of Block 15-71, towards mapped water licenses on Mitch Bronaugh's property, slopes are generally between 35 to 45% and underlain by some silt (10 to 20%) to silty (10 to 35%) sand till, with a low coarse fragment content (<25%). Commonly there is a thin (0.5 to 0.8m) loose weathered till layer overlying thicker compact to dense till. There are gullies of varying size in the till, commonly with 55 to 65% gradient side slopes with a 2 to 4m deep incision.

Water intake PD28283 is on a spring in one of these gullies, which was traced upslope for about 500m (GPS 009 to 012), where it pinches out at the base of a short bedrock bluff. There was intermittent surface flow extending for about 200m upslope of the intake site (GPS 009 to 010), above which there was little or no evidence of surface flow in the gully. No evidence of surface flow was observed on the colluvial and rocky areas upslope of GPS 012.

Springs on this slope face may be fed by subsurface water flows infiltrating into upper bedrock discharging lower on the slope through discontinuities in the glacial deposits, and/or by water that infiltrates through the upper more permeable loose weathered till layer and travels downslope at the weathered/unweathered till interface.

Mr. Bronaugh reports that while later in the dry season there are no surface flows upslope of the spring, there is always water in the spring. This and the fact that there are two springs at roughly the same elevation suggest that there is some bedrock component to the subsurface flow system feeding these springs. If so, precipitation infiltrating on rocky areas upslope of till deposits, including the area of Block 15-71, will likely contribute to spring flow.

To the southwest of the block there are some short steep rock bluffs, but generally colluvial with lesser till slopes with moderate (30 to 50%) gradients extend several hundred metres down the valley wall, to till and glaciofluvial deposits on the lower valley walls adjacent to Falls Creek. Air photos and terrain mapping (Utzig and Carver, 1999) shows that there is gullying and slumping in these lower valley wall glacial deposits and they are mapped as Class IV and V, or potentially unstable and unstable respectively. Except for this lower valley wall terrain and a small area mapped as potentially unstable downslope of the north end of the block, all other slopes within and downslope of the proposed block are mapped as Classes I to III, or stable.

4.1.2 Other Proposed Blocks (15-53 and 15-55)

Proposed Block 15-55 is located east of Garrity Creek with only a small portion within the Garrity Creek watershed. An inspection of the proposed block area was made, focusing on the western boundary of the block. Portions of the hillside above Garrity Creek are designated as Terrain Stability Hazard Class (TSHC) IV and V (potentially unstable and unstable). The steeper slopes on the valley wall were characterized by

steep gullies in till materials with occasional bedrock controls. This high hazard terrain is directly connected to Garrity Creek below.

The remainder of the block is on a gently sloping bench (35-40%) with well-drained colluvial soils, fractured bedrock and occasional tills. No evidence of surface drainage was observed in the block or along the existing road and sediment transport potential was limited.

Proposed Block 15-53 was not field inspected due to its small contributing area into Garrity Creek, relatively gentle terrain and poor connectivity to surface streams and/or water intake sites (see Figure 2).

4.1.3 Proposed Roads

Only two new roads are required to access the proposed beetle salvage blocks, both of these were associated with Block 15-71. Proposed Block 15-53 will be accessed through the Smallwood Creek watershed. Proposed Block 15-55 can be harvested from the existing road network. Sections of both proposed roads were inspected for drainage, sediment and stability issues.

Spur 100 is located on predominantly 25 to 40% rock and thin colluvial slopes within the proposed block. In the short section outside of the block, it crosses predominantly 40 to 45% colluvial slopes, with one 30m long section crossing a 57% gradient, blocky, talus slope. Immediately downslope of the alignment there are short rock bluffs and moderate gradient, thin colluvium over rock slopes. Below about 1200m elevation, slopes are underlain by increasingly thick glacial sediments, with some small gullies, as described above in Section 4.1.1. Spur 100 crosses the slope above the Bronaugh property springs (PD28283 and PD28284). No continuous defined gullies exist between the proposed road location and the water intake sites.

Spur 200 is located on predominantly gentle gradient rock and colluvial slopes within the proposed block. In the section observed west of the block, it crosses predominantly well-drained colluvial slopes with 45 to 55% gradients. There is one short section crossing a 65% gradient angular talus slope. This section of the alignment also crosses a small swale that is the headwater area of a mapped tributary stream of Falls Creek (GPS 006). The swale base gradient is 25% at the crossing and no sign of surface flow was observed. At GPS 003 the only occurrence of surface seepage in the block or immediate downslope area was observed. Surface seepage extended for about 20m before re-infiltrating in the base of a swale. This wetter upland area may be connected to the mapped stream that is shown as connecting to Falls Creek. However, no visible surface channels were found to exist crossing the road to the community intake on Falls Creek, directly below this area. No stream crossings are required by either proposed road.

4.1.4 Existing Roads

Existing roads and road cuts in the studied portions of the watersheds were inspected for soil conditions and potential drainage issues. Soils were pre-dominantly coarse grained and well-drained, resulting in limited surface runoff along alignments. Evidence

of sustained flow in ditchlines was infrequently observed. Where occasional finer-grained morainal (till) deposits were noted, seepage, road surface and ditch flows were noted. Many of the spur roads in both watersheds were suitably deactivated.

The following table locates and briefly describes existing or potential problem sites identified during the field reconnaissance of the Falls and Garrity Creek watersheds. Often these problems/issues are simply maintenance issues, and can be easily addressed when roads are 'reactivated' for proposed logging operations. A relative priority for each site has been assigned based on the extent of the problem and the current level of risk to watershed values.

Table 1: Problem Sites Identified during the Field Reconnaissance

GPS Point	Problem Description	Suggested Mitigation	Risk to Water Resources	Relative Priority	Photo #
506 to 508	Cutslope failure in fine-grained soils. Ditch plugged. Sediment deposits on forest floor downstream of culvert.	Clean ditch, re-slope and re-seed cutslope. Consider armouring cutslope toe.	L	L	Photo B 3497-3504
523 & 526	Old road/trail is intercepting seepage flows from gully upslope. Some flow following road. (Private Land)	Hand-dig cross-ditches to ensure drainage directly across the road.	M	M	3517, 18,20, 24

A traverse of an old road leading from proposed Block 15-71 down across the slope above the settlement of Beasley was undertaken in the company of M. Bronaugh, being mostly on his property (GPS 521-530). Mr. Bronaugh suggested the road was possibly 80 to 100 years old. At least one 60cm diameter Douglas fir was noted growing in the fillslope, corroborating the approximate age of the road. Cuts along the relatively narrow road seldom exceeded 1m in height, and no culverts had been installed (Photo C & D). At a few locations where the road cut across defined gullies, some seepage across the road was noted (GPS 523, 526 see Table 1). The remainder of the road appeared dry and stable, and little evidence of surface and/or near surface drainage interception was observed. After a switchback near a cedar grove (GPS 527), a series of old roads and driveways were followed back toward PD28283. Water intakes were noted at GPS 528, and downstream of GPS 529.

The original Falls Creek FSR was foot-traversed from the community intake to an abandoned bridge crossing site. Several old road fill failure sites were crossed along the way, all of which appeared to be no longer active and re-vegetating. Handwork had been undertaken at some of these sites to improve drainage and 'deactivate' (Putt 2001). None of the failures appeared to originate above the road grade and connectivity to Falls Creek was variable, depending on the position of Falls Creek and the floodplain width below. Sediment production at these sites appeared to be well mitigated, and further work was considered to be of little benefit.

4.1.5 Mainstem Channels

Falls Creek

The Falls Creek mainstem was inspected at easily accessible locations from its outlet into Kootenay Lake (GPS 500) up to an old road crossing (GPS 539) above the community intake. Flow in the creek was at a low-moderate stage and appeared essentially clear despite recent precipitation. Approximately 75mm of rain had fallen over the preceding 10 days (Environment Canada – Data for Nelson).

At the confluence, the creek discharges from a bedrock controlled canyon (including a series of waterfalls) into a deep pool formed by the railway grade (Photo E, F). Six 1200mm culverts provide drainage through the rail bed. Despite being an obvious sediment trap, the pool was clear with a cobble bed, indicating low bed- and sediment loading at this end of the system.

At the highway crossing (GPS 501), Falls Creek flows through an extended length of 2000mm corrugated steel culvert, to pass beneath two road grades. A concrete drop structure with steel trash rack has been constructed to protect the inlet (Photo G). Deposition of gravel and cobble sized bedload has occurred up to the invert elevation. A pile of burnt wood nearby suggested occasional clearing of woody debris at the inlet is necessary. The estimated gradient of the culvert was 23%, while the channel gradient upstream was approximately 8%. Some length of bedrock canyon may have been filled to provide bedding for the culvert.

Through much of the section above the Highway crossing and below the community intake (PD61674) the channel is assumed to flow through a steep-sided, bedrock controlled canyon.

At the community intake, a small weir has been constructed, causing a sediment wedge (aggradation) upstream of it (Photos H, I). The intake is a slotted pipe set in the accumulated gravels, providing some filtering at source (M. Bronaugh, Pers. Comm.). On the 17th of June, two days after the site visit, approximately 45mm of rain fell in the Nelson region ((Environment Canada – Data for Nelson). Mr. Bronaugh returned to the intake site and took some photographs at high flow (Photo J, K). Although somewhat discoloured, flows at the site do not appear to be high in suspended sediments (considering the amount of recent rainfall, flow stage and the occurrences of landslides and degraded upstream channel as reported in the previous IWAP).

In an email dated June 17th, 2005, Mr. Bronaugh suggested that local residents are not normally aware of turbidity/colour in the creek as it is not visible from any residence or road crossing. In general, local water users appear satisfied with the current condition of the creek and the quality of the water abstracted. Well-configured intakes and long piping distances (including storage) may be partly responsible for keeping suspended sediment materials away from household taps.

Upstream of the intake, the Falls Creek mainstem channel was a slightly aggraded, but relatively stable boulder-cascade with coarse textured bedload, mossy lag-boulders, well-armoured and vegetated banks. Wood provided some function in channel stability although it was often marginal. Several non-alluvial (bedrock controlled) sections were

noted between the community intake and the old bridge site. No indications of elevated peak flows or sediment loading were observed. This channel type is likely not sensitive to minor alterations in flow regime.

Two surface water tributaries were identified along the section of road (original Falls Creek FSR) between the residences in Beasley and the old bridge site. A small tributary (<0.5m wide) crossed the road in a hand-dug ditch (GPS 535) and disappeared into a 30m wide floodplain below. A larger tributary (1.3m wide x 0.35m deep) crossed the road at GPS 540, just upstream of the community intake site (Photo L). Mr. Bronaugh stated that this creek runs 'rusty' on occasion, but likely enters the creek below the actual intake. This tributary is probably connected to the mapped tributary that originates just west of the northwest corner of proposed Block 15-71 on the ridge above (although this was not confirmed on the ground). The lack of observed tributaries downstream of this point diminishes the likelihood of a surface water connection existing between the proposed block and Falls Creek. It also reaffirms that most of the proposed harvest drains downstream of the point of interest.

Garrity Creek

The Garrity Creek mainstem was inspected at the lower end in the vicinity of the licensed water intakes (GPS 502), and in the area of forest development upstream (GPS 503). Between these points the channel is inferred to be confined in a bedrock-controlled canyon.

Garrity Creek crosses beneath Beasley Road through a 1200mm culvert protected by three steel posts (debris grizzly). Water intakes were installed in the creek upstream and downstream of the crossing. Above the road, the creek is steep (>28%) with steeper side-slopes and bedrock controls. The creek appeared mostly stable with mossy lag boulders and 1m diameter cedars growing to the stream edge. Some evidence of coarse bedload (angular, cobble-sized) and old cobble levees/lobes were observed (Photo M, N). No tree scars or trim lines were apparent. Some small woody debris jams/deposits were noted. The survey ended where the channel was incised in bedrock.

At the Garrity Creek FSR crossing, a different stream type was found. The channel gradient was 5%, with stable mossy banks, gravel substrates, riffles and functioning woody debris (Photo O). The channel had a 30m wide floodplain with older fluvial terraces. Riparian vegetation was intact with mature fir and cedar, ferns and devil's club. While currently stable and in good condition, this stream type would be sensitive to forest development, especially riparian harvesting.

4.2. Equivalent Clearcut Area

4.2.1 Falls Creek

As discussed in Section 3.2.1., a detailed update of ECA levels in the Falls Creek watershed was not undertaken. In the original IWAP (Carver et.al. 2000), the weighted ECA was calculated 22.2% of watershed area (or 661ha). Making general assumptions about tree growth and hydrologic recovery it is expected that there would be approximately a 5% decrease in the weighted ECA in the 6 years since 1999. This would put the current ECA at 17.2% (or 512ha). The weighted ECA of the portion of the

proposed Block 15-71 within the watershed upstream of the community intake is 6.3 ha [3.0 ha below H60, plus 2.2 x 1.5 ha above H60]. This will amount to a 0.2% increase in the weighted ECA for the watershed. Based on the recovery estimate and the small amount of proposed harvest, it is reasonable to assume that the ECA level will be maintained within the range (<20%) recommended by the previous IWAP.

For comparison purposes, current forest cover information was used to calculate ECA in the Falls Creek watershed (using the same method used for evaluating Garrity Creek). Existing forest cover openings and burned area polygons (NP-BURN) were both evaluated for hydrologic recovery using WinVYDP and VRI data. All of the burns and most of the openings were projected and found to be 90% recovered (according to tree height only). Using this approach, the weighted ECA for the Falls Creek watershed was calculated to be 5.5%.

Further discussion of ECA and potential peak flow alteration in Falls Creek is provided in Section 5.1.1.

4.2.2 Garrity Creek

The following table summarizes the existing and proposed ECA for the Garrity Creek watershed. Detailed calculations are provided in Appendix B.

Table 2: Equivalent Clearcut Area (ECA) for the Garrity Creek Watershed

Mapsheet	*Watershed Name*	*Watershed Area (ha)*	*Existing ECA %**	*Proposed Harvesting Area (ha)*	*Proposed ECA %**
82F043, 53	Garrity Creek	393	20.2	8.9	23.0

*** ECA above H60 line is weighted by a factor of 1.5 as per IWAP (Anonymous, 1999)**

Results of this analysis are incorporated into the hydrologic risk assessment developed in the following section. Discussion of ECA and potential peak flow alteration in the Garrity Creek watershed is also provided in Section 5.1.2.

5.0 DISCUSSION & RECOMMENDATIONS

5.1. Hydrologic Risk Assessments

Qualitative hydrologic/geomorphic risk assessments with respect to proposed development in the Falls Creek and Garrity Creek watersheds are presented in the following sections.

5.1.1 Falls Creek

In the previously completed IWAP (Carver et.al. 2000), a risk assessment was presented based on assessed indicators and the results of field reconnaissance. As there has been no forest harvesting in the watershed since that assessment, the existing level of risk will have decreased as a result of hydrologic recovery and road deactivation completed in the watershed (Putt 2001).

The incremental risk associated with the currently proposed development on a watershed scale is small. Under the IWAP, and other risk assessment procedures (e.g. Green 2005), risks are evaluated with respect to change in peak flow, sediment production and delivery, channel stability and riparian function. The incremental risk of the proposed harvest with respect to the Falls Creek watershed POI (the community intake) is discussed for each hazard category in the following paragraphs. The risks to other downslope water sources are discussed in Section 5.2.

Risk of Increased Peak Discharge

As previously described, the total increase in ECA represented by the proposed harvesting is 0.2%. The area of harvest straddles the H60 line elevation. In a watershed dominated by alpine snowmelt, any harvesting below the H60 elevation has been found to have a negligible effect on peak discharge due to runoff desynchronization (Schnorbus & Alila 2004). Block 15-71 is also well away from other openings in the upper watershed, allowing for further desynchronization. With or without harvesting, in either case, the ECA will increase with tree mortality caused by beetle.

The incremental risk of peak flow increases in Falls Creek as a result of the proposed harvesting is very low. The current ECA for the watershed was estimated at 17.2%. Without knowing the distribution of this ECA with respect to elevation, comments on the residual risk of peak flow effects in the watershed as a whole cannot be made.

Risk of Increased Sediment Delivery

Rapidly drained soils and little evidence of surface runoff were observed in proposed Block 15-71 or along proposed road alignments. Sediment transport from surface erosion sources to streams is unlikely. Coarse-grained soils are erosion resistant and allow infiltration as well as sediment filtering.

There are two TRIM mapped creeks just west of Block 15-71 that appear to connect to Falls Creek, one just above the community water intake. Flowing water was observed at GPS 540, entering the creek close to the intake that may be associated with the mapped watercourse just inside the watershed (see Section 4.1.5). It is theoretically

possible that drainage diversions from roads or trails in Block 15-71 could initiate a landslide in this area, which could in turn affect water quality at the intake.

It is recommended that a detailed TSA be carried out to determine the potential landslide hazard along and below the western edge of proposed Block 15-71 and portions of Spur 200 above the mapped gullies.

Until this risk is assessed, comments on the incremental risk of sediment increases related to the currently proposed harvesting cannot be made.

Though the information is anecdotal, water quality at the community intake is generally good (See Section 4.1.4). Suspended sediment levels during a significant rainfall/runoff event appeared elevated but not extreme. This may be an indication that efforts at road deactivation and landslide revegetation have been effective at reducing sediment production and delivery in the watershed.

Risk of Decreased Riparian Function & Channel Stability

The incremental risk of decreased riparian function related to the currently proposed harvesting and roads in the Falls Creek watershed is low. No alluvial channels exist within the proposed block and no stream crossings are required. Risks to channel stability can be similarly expressed. The only possible risk to either of these processes would be the initiation of a landslide as described above, further justifying the recommendation to complete a TSA to fully ascertain risks.

5.1.2 Garrity Creek

No previous risk assessments have been prepared for the Garrity Creek watershed. Following a framework recently published by K. Green of Apex Geoscience Consultants of Nelson (Green 2005), a qualitative assessment of hydro-geomorphic risk has been developed for the watershed below. Risks of increased peak flow, increased sediment delivery and decreased riparian function are assessed based on field observations of conditions and disturbance. Risks are evaluated by combining channel sensitivity (Low, Moderate and High) with hydrological hazard (i.e. likelihood of change). This assessment method is preferred to the previously used 'report card' approach because it incorporates inherent natural sensitivities that vary from watershed to watershed. The rationale for assigned sensitivity and hazard ratings are based on observations of channel and hillslope conditions and are provided in each case.

IMPORTANT NOTE:

The hydrologic risk assessment presented below is based on combining natural channel sensitivity and the total (existing & proposed) level of development in the watershed. These risk ratings do not represent incremental risks associated with the proposed development. A watershed could be assigned a 'Moderate' risk rating in the absence of any development, if natural channel sensitivities are high.

This risk analysis assumes that pine beetle related stand mortality is contained within the proposed harvest area. If stand mortality becomes more widespread and occurs in different parts of the watershed, impacts and risks could be greater than those

presented here.

Risk of Increased Peak Discharge

Channel Sensitivity: Moderate (areas of both high and low sensitivity)

Rationale:

- Lower channel in the vicinity of water licenses is not sensitive due to bedrock controls. Channel in the upper watershed (above Garrity Creek FSR crossing) is lower gradient, transport limited riffle-pool with coarse sand and gravel substrates. This area would be sensitive to small changes in flow regime, buffered somewhat by abundant LWD function and overflow channels. Therefore the sensitive portion of the channel is in the upper watershed, where cumulative effects are likely to be less prevalent.
- Small watershed with little evidence of frequent flood events. Lower elevation headwaters with limited alpine area in watershed.

Likelihood of Change: Moderate (indicating 'could potentially occur')

Rationale:

- Assuming the current level of proposed harvesting and/or beetle kill (ECA 23%) in a moderate to steep gradient, non-alpine watershed.
- Existing and proposed development are well-distributed around the watershed with respect to aspect and elevation.
- Minimal road density and ditches are not concentrating runoff and/or extending the stream network.
- Proposed blocks occupy very small areas in the watershed.

Peak Flow Risk (after K. Green 2005 – Table 1)

Moderate (Channel Sensitivity) **x Moderate** (Likelihood of Hydrologic Hazard) = **Moderate** (Risk)

Risk of Increased Sediment Delivery

Channel Sensitivity: Moderate (areas of both high and low sensitivity)

Rationale:

- Channel in the upper watershed (above Garrity Creek FSR crossing) will allow for sediment filtering and storage. Frequent low gradient sections with unconfined alluvial channels and abundant LWD jams.
- Lower channel is bedrock controlled with continuous gradient and little opportunity for storage and/or filtering. Sediment will travel rapidly to the area of intakes.

Likelihood of Change: Moderate (indicating 'could potentially occur')

Rationale:

- Watershed is small with no opportunity for sediment dilution.
- Low density of roads and stream crossings. Most existing roads and crossings have been deactivated. Road drainage is not connected to stream network.
- Coarse-grained soils with high coarse fragment content are erosion resistant and allow infiltration as well as sediment filtering.
- Steep valley walls mapped as unstable are frequently coupled to the mainstem.
- Existing blocks and roads are outside mapped potentially unstable or unstable terrain that is connected to the stream.
- Proposed Blocks 15-71 and 15-53 and are not connected to any streams.
- Proposed Block 15-55 is mapped as overlying and directly upslope of steep unstable terrain mapped directly connected to the Garrity Creek mainstem.

Sediment Delivery Risk (after K. Green 2005 – Table 1)

Moderate (Channel Sensitivity) **x Moderate** (Likelihood of Hydrologic Hazard) = **Moderate** (Risk)

Different risks could be assigned for the differing channel types, in which case the lower mainstem would be assigned a **High** risk rating, because of the proximity of Block 15-55 to unstable terrain connected to Garrity Creek. In order to reduce risks, the western boundary of proposed Block 15-55 should be kept away from unstable terrain. **A detailed TSA for the block is recommended to accurately identify the limit of any unstable terrain and provide mitigative measures within the block to prevent harvesting or drainage redirection onto this terrain.** Following this recommendation will maintain a moderate sediment delivery risk to Garrity Creek.

Risk of Decreased Riparian Function

Channel Sensitivity: Moderate

Rationale:

- Lower channel is not dependent on functioning wood for stability due to bedrock controls. Channel in the upper watershed (above Garrity Creek FSR crossing) is dependent on LWD for stability
- Shade and cover are not important due to orientation and absence of fish. Stream temperature not an issue.

Likelihood of Change: Low (indicating 'not likely to occur')

Rationale:

- In existing and proposed harvesting, most riparian vegetation is intact and buffers have been maintained.
- Low existing density of roads and stream crossings. No new roads planned.
- Stream temperature not an issue.

Sediment Delivery Risk (after K. Green 2005 – Table 1)

Moderate (Channel Sensitivity) **x Low** (Likelihood of Hydrologic Hazard) = **Low** (Risk)

Summary

Risk ratings for Garrity Creek are summarized in the following table.

Table 2: Summary of Hydrologic Risks in the Garrity Creek Watershed.

Risk of Increased Peak Discharge	Moderate
Risk of Increased Sediment Delivery	Moderate
Risk of Decreased Riparian Function	Low

It is important to note, that the proposed harvesting does not increase the risk rating in any of the assessed categories. The contribution in ECA generated by the small pieces of the proposed blocks which actually fall within the watershed boundaries is relatively minor. When one considers that the openings may eventually occur through beetle mortality, the incremental risk of harvesting is negligible. In fact, harvesting may mitigate long term risk to water resources by decreasing fuel loading and reducing the risk of a severe burn in the standing dead wood left by beetles. Severe burns are more likely to alter soil infiltration and terrain stability than salvage operations. In addition, any action to control the spread of beetle infestations to other mature pine stands could potentially reduce future ECA levels.

5.2. Potential Effects on Springs Downslope of Proposed Blocks

Forest harvesting and road construction undertaken in an area of groundwater recharge can potentially affect downslope spring discharge. Since groundwater recharge areas may not correspond to surface contributing areas, and are therefore difficult to delineate, the conservative assumption made here is that all area proposed for harvesting upslope of a spring could potentially be in that springs recharge area. That is, most of Block 15-71 could be in the recharge area of the springs on the Bronaugh property (PD282-83 and 84) and several others downslope (PD282-82,85,86,87 and PD76061). Depending on subsurface conditions, any of the mapped 'points of diversion' between Falls and Garrity Creeks could theoretically be affected by changes in surface drainage and/or forest cover (harvest and/or beetle kill) in the vicinity of proposed Block 15-71. Detailed subsurface investigations of groundwater movement/connectivity downslope of Block 15-71 were considered beyond the scope of this investigation; however, the following general assumptions are made based on our field assessments, inferences of subsurface conditions and existing forest hydrology research:

5.2.1 Effects of Forest Cover Reduction

Research has shown that stand canopy removal in a snowmelt dominated coniferous forest will generally result in no change or a slight increase in annual water yield and in late season low flows. The physical processes involved in these increases are well understood and documented. Following logging there is reduced snow interception loss and often increased snow accumulations within the openings. This is coupled with reduced growing season rain interception and reduced evapo-transpiration losses due to water withdrawal by trees. Noting that there is likely to be high pine beetle related mortality of the stand proposed for harvesting, with or without harvesting stand canopy reduction will occur in the next several years.

Most research findings on the effects of forest harvesting in relation to growing season soil moisture and/or low flows have been either no significant effects, or, as in the case of all the following references, increased growing season low flows were observed following logging (Burton, T.A. 1997, Cheng, J.D. 1977, Cheng, J.D. et.al. 1982, Dickison, R.B.B. et.al. 1981, Fahey, B. and Jackson, 1997, Harr, R.D. 1976, Harr, R.D. 1979, Harr, R.D. et.al. 1982, Hornbeck, J.W., et.al. 1997, Kattelmann, R.C. et.al. 1983, Keppeler, E.T. and Ziemer. 1990, Lynch, J.A., et.al. 1972, Rothacher, J. 1970, Swanson, R.H., et.al. 1986, Swanson, R.H. and Hillman. 1977, Ziemer, R.R. 1964.)]

While there are virtually no studies that found decreases in water yields following logging, studies have found decreases in low flows following harvesting where: fog-drip is a significant precipitation component; the stand was replaced by vegetation that consumes more water than the original stand (phreatophytes); or where harvesting practices caused widespread soil compaction and a reduction in surface infiltration rates. Fog-drip is not a significant source of precipitation in this area. With normal good harvesting and silviculture practices the latter two effects will not occur at this site. A free-growing conifer stand should not cause any significant increase in water demand. On the fractured bedrock and coarse grained soils at this site, with normal good ground-skidding practices that meet site disturbance guidelines, there should be no measurable decrease in overall infiltration.

It is concluded that the local effect of beetle kill and/or harvesting will be some increase in soil moisture and groundwater recharge at the site. Groundwater originating in the rocky upland area will discharge lower on the valley walls and continue to supply stream flow and springs. If the block area is a significant contributor to flows at one or both springs on the Bronaugh property (PD28283 and PD28284), there may be some increase in flow volume. If not, there will be no noticeable effect on spring flows. Similar conclusions can likely be drawn for all the spring water intake sites shown downslope between Falls and Garrity Creeks.

5.2.2 Effects of Proposed Roads

Proposed Spur 100 will cross the hillside approximately 650m upslope of the Bronaugh property springs (PD28283 and PD28284). The alignment is generally on thin colluvium and rock, likely with some thin pockets of till. Little evidence of significant subsurface seepage was observed being intercepted in colluvium and rock road cuts in roads to the east in Garrity Watershed. Seepage was noted in till on trails downslope of the spur alignment While it appears that most of the spur crosses an area where precipitation infiltrates rapidly to fractured bedrock, it is low enough on the slope that there is some uncertainty about the extent of till and hence more shallow subsurface drainage, which could be intercepted by road cuts. Given the downslope water licenses which are dependant on subsurface flows, it would be prudent to manage possible road related disturbances of this surface and near-surface flow cautiously.

To achieve minimal subsurface flow interception road cut slope height should be minimized. Road construction options which will achieve this are minimal running surface widths and using larger fills on lower gradient hillslopes. Temporary roads that are constructed, used and deactivated in a single dry season can be out-sloped or built with little or no ditch. The least impact will be achieved by a temporary winter road constructed partially with snow, if the climate and weather permit.

To ensure uninterrupted passage of surface and near surface drainage, and avoid diversion of flows across the slope, cross drainage should be provided through the road grade at all seeps and (dry) gullies.

5.3. Review of Falls Creek IWAP (Carver et.al. 2000) Recommendations

Carver had recommended that the ECA in Falls Creek should be managed between 15 and 20% (weighted). Based on an estimate of hydrologic recovery since 1999, the currently proposed harvest area will remain in that range.

Other general recommendations for forest development in Falls Creek, were presented in Sec 5.2.4 of that document as follows:

"Development proposals which possess some or all of the following characteristics are preferred:

1. *Non-riparian areas*
2. *Dry areas with limited linkage to stream channel network*
3. *Single-tree or group selection (preferably with >70% retention to limit ECA increments)*
4. *Winter logging*
5. *Harvest below H60 line*
6. *Long forwarding trails*
7. *Rocky ridges (road building)*

Further development should be located on "terrain outside areas of high and very high hazard of sediment yield. . . . and avoid stream crossings in areas of high and very-high sediment potential of sediment delivery or landslide-induced stream sedimentation. Where it is not possible to avoid these areas Level A Stability Field Assessments [Terrain Stability Assessments] should be carried out to confirm the terrain mapping and prescribe detailed mitigation measures which prevent sediment delivery to the channel network."

The currently proposed Block 15-71 was not in the plan at time of the previous IWAP (Carver et.al. 2000) and hence no specific recommendations related to harvesting in that area were made.

Block 15-71 meets the physical conditions of bullets 1, 2, 5 and 7. That is it does not impact any riparian area, it is located on a dry rocky ridge, below the H60 line and with limited linkage to the stream channel network.

The aim of bullet 3 was to 'limit ECA increments'. The ECA increment caused by the portion of Block 15-71 that falls within the Falls Creek watershed boundary is small. In addition, 70% retention serves little hydrological purpose in pine beetle salvage blocks where the dominant species is Lodgepole Pine. This does not preclude a harvesting system with retention of species other than pine for other values, although from a standpoint of reducing ECA, this is not necessary.

The two remaining recommendations – for winter logging and long forwarding trails – are presumably made to limit site disturbance during ground based harvesting and to limit the effects of roads. Within the proposed Block 15-71, underlying bedrock and coarse grained

soils on predominantly gentle slopes will not be particularly susceptible to ground disturbance, such as compaction, which could affect infiltration and thus groundwater recharge. **Normal good harvesting practices within site disturbance guidelines during the dry summer period or during winter with an adequate snowpack and/or frozen ground should not result in a significant change to infiltration characteristics at this site. Winter harvesting under the conditions described above will provide the least risk of site disturbance.**

With the roads (Spurs 100 and 200) as proposed, forwarding trails will be up to 300m long. Recommendations to mitigate the potential hydrological effects of the spur roads are discussed in Section 5.2.2. The potential landslide and sediment delivery hazard from Spur 200 should be addressed in TSA as recommended in Section 5.1.1.

5.4. Other Hazards

If the beetle-kill stand on the exposed ridge of Block 15-71 is left un-harvested, there will likely be increased fuel loading and fire risk due to lightening strike. A severe burn can affect surface soil characteristics and greatly reduce infiltration, resulting in serious impacts to peak flows, flooding, slope and channel stability, and increased risks to water supplies, property, human safety and life (Jordan et. al., 2004; GACL, 2005). Managing this risk by harvesting can reduce fire and post-fire risks, if harvesting practices are adopted which ensure a minimal post-harvest fuel load.

The analysis and recommendations in this report assume normal good harvesting and road building practices, and makes some specific recommendations regarding development, which, if followed, should result in low hydrological impacts. However the recommendations in this report will only be effective in they are implemented properly. **It is recommended that BCTS ensure that there are proper planning and operational procedures in place, including adequate supervision of on-site activities, to ensure that the intent of the recommendations in this report are met during operations.**

5.5. Summary of Recommendations

The following list summarizes the recommendations developed in this assessment to mitigate the level of hydrologic risk and protect water resources in the vicinity of the Falls and Garrity Creek study area from potential impacts of forest development:

Falls Creek

- Normal good harvesting practices within site disturbance guidelines during the dry summer period or during winter with an adequate snowpack and/or frozen ground should not result in a significant change to infiltration characteristics in proposed Block 15-71. Winter harvesting under the conditions described above will provide the least risk of site disturbance.
- To achieve minimal subsurface flow interception road cut slope height should be minimized. Road construction options which will achieve this are minimal running surface widths and using larger fills on lower gradient hillslopes. Temporary roads that are constructed, used and deactivated in a single dry season can be out-sloped or built with little or no ditch. The least impact will be achieved by a temporary winter road constructed partially with snow, if the climate and weather permit.
- To ensure uninterrupted passage of surface and near surface drainage, and avoid diversion of flows across the slope, cross drainage should be provided through the road grade at all seeps and (dry) gullies.
- It is recommended that a detailed TSA be carried out to determine the potential landslide hazard along and below the western edge of proposed Block 15-71 and portions of Spur 200 above the two mapped watercourses/gullies (near the northwest corner of the block).
- Address low priority road maintenance sites (Table 1 – Page 10) when equipment is available in the area.
- Review upper basin hydrologic recovery (ECA) if any future proposals include harvesting above the H60 elevation.

Garrity Creek

- A detailed TSA for the proposed Block 15-55 is recommended to accurately identify the limit of any unstable terrain and provide mitigative measures within the block to prevent harvesting or drainage redirection onto this terrain.

General

- Review beetle susceptibility for the remainder of the watersheds. If extensive, non-salvage logging should be deferred to minimize potential ECA level resulting from tree mortality.
- Manage for low fuel load in harvested areas.
- Ensure that there are proper planning and operational procedures in place, including adequate supervision of on-site activities, to ensure that the intent of the recommendations in this report are met during operations.

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APPENDIX A

Water License Reports

LWBC
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Water Licences Report

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Licence No	WR Map/ Point Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C056943	5301B WW (PD28261)	Falls Creek	Irrigation Local Auth	1.875	AF	T	N	BONNINGTON IMPROVEMENT DISTRICT C/O DAVID TACON RR 1 COMP 14 SITE 12 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19050525	0
"	"	Falls Creek	Waterworks Local Auth	182500	GY	T	N	BONNINGTON IMPROVEMENT DISTRICT C/O DAVID TACON RR 1 COMP 14 SITE 12 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19050525	0
C062518	5301B S6 (PD28266)	Falls Creek	Domestic	500	GD	T	N	JENSEN KIRK E & COLETTE M RR 1 SITE 7 COMP 13 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19791009	0
C063097	5301B WW (PD28261)	Falls Creek	Storage	2	AF	T	N	FORTISBC INC 5TH FLOOR 1628 DICKSON AVENUE KELOWNA BC V1Y9X1	NEL - SLOCAN JUNCTION	Current	N/A	19300825	0
"	"	Falls Creek	Waterworks (Other)	10000	GD	T	N	FORTISBC INC 5TH FLOOR 1628 DICKSON AVENUE KELOWNA BC V1Y9X1	NEL - SLOCAN JUNCTION	Current	N/A	19300825	0
	5301B S6	Falls						ACHSEN MICHEL C	NEL - SLOCAN				

C102045	(PD28266)	Creek	Domestic	500	GD	T	N	RR 1 SITE 7 COMP 31 SOUTH SLOCAN BC V0G2G0	JUNCTION	Current	N/A	19791009	19910827
C102229	5301B S6 (PD28266)	Falls Creek	Domestic	500	GD	T	N	ELLIS ELIZABETH D SITE 7 COMP 43 RR 1 4683 BAINS RD SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19720203	19910827
C109436	5301B X7 (PD70703)	Falls Creek	Domestic	1000	GD	T	N	MOREAU JOSEPH D P & MARIANNE 625 12 ST COLD LAKE AB T9M1B1	NEL - SLOCAN JUNCTION	Current	N/A	19730816	19950424
C110190	5301B S6 (PD28266)	Falls Creek	Domestic	500	GD	T	N	KUCH CAMERON G RR 1 SITE 7 COMP 34 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19720203	19960326
C111411	5301B N7 (PD61674)	Falls Creek	Irrigation Local Auth	6.25	AF	T	N	BONNINGTON IMPROVEMENT DISTRICT C/O DAVID TACON RR 1 COMP 14 SITE 12 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19770315	19961026
C111412	5301B N7 (PD61674)	Falls Creek	Waterworks Local Auth	54750000	GY	T	N	BONNINGTON IMPROVEMENT DISTRICT C/O DAVID TACON RR 1 COMP 14 SITE 12 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19810716	19961026
C111903	5301B X7 (PD70703)	Falls Creek	Domestic	1000	GD	T	N	JENNINGS LINDA J BOX 76 CRESCENT VALLEY BC V0G1H0	NEL - SLOCAN JUNCTION	Current	N/A	19730816	19970210
C111908	5301B X7 (PD70703)	Falls Creek	Domestic	500	GD	T	N	RICALTON KEN 739 HWY 3A UNIT 8 NELSON BC V1L6M4	NEL - SLOCAN JUNCTION	Current	N/A	19770404	19970210
								BRONAUGH JOHN M & BIGGIN					

C111909	5301B X7 (PD70703)	Falls Creek	Domestic	500	GD	T	N	JUDITH H 712 CARBONATE ST NELSON BC V1L4P8	NEL - SLOCAN JUNCTION	Current	N/A	19770223	19970210
C111913	5301B X7 (PD70703)	Falls Creek	Domestic	1000	GD	T	N	SWETLISHOFF WILLIAM ET AL RR 1 SITE 6 COMP 11 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19730806	19970210
"	"	Falls Creek	Irrigation	8.75	AF	T	N	SWETLISHOFF WILLIAM ET AL RR 1 SITE 6 COMP 11 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19730806	19970210
C111914	5301B X7 (PD70703)	Falls Creek	Domestic	500	GD	T	N	KENT MICHAEL ANDREW RR1 SITE 6 COMP 1 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19730728	19970210
"	"	Falls Creek	Irrigation	5	AF	T	N	KENT MICHAEL ANDREW RR1 SITE 6 COMP 1 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19730728	19970210
C111917	5301B X7 (PD70703)	Falls Creek	Domestic	1000	GD	T	N	TO BE DETERMINED PLEASE CONTACT NEAREST LAND & WATER BC OFFICE	NEL - SLOCAN JUNCTION	Pending	Apportionment Pend	19770519	19970210
"	"	Falls Creek	Irrigation	7	AF	T	N	TO BE DETERMINED PLEASE CONTACT NEAREST LAND & WATER BC OFFICE	NEL - SLOCAN JUNCTION	Pending	Apportionment Pend	19770519	19970210
C111918	5301B X7 (PD70703)	Falls Creek	Domestic	500	GD	T	N	FUHR BRUCE W & DEBORAH A RR 1 SITE 6 COMP 18 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19770530	19970210
C111919	5301B X7 (PD70703)	Falls Creek	Domestic	500	GD	T	N	PHELAN BRIAN J & DEBORAH E RR 1 SITE 7 COMP	NEL - SLOCAN JUNCTION	Current	N/A	19770223	19970210

								46 SOUTH SLOCAN BC V0G2G0					
C113613	5301B X7 (PD70703)	Falls Creek	Domestic	500	GD	T	N	COWAN GORDON P RR 1 SITE 7 COMP 50 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19720203	20000307
C113617	5301B X7 (PD70703)	Falls Creek	Domestic	500	GD	T	N	BARABONOFF NATALIE SUSAN RR 1 SITE 7 COMP 9 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19720203	20000307
C116747	5301B X7 (PD70703)	Falls Creek	Domestic	500	GD	T	N	FRANSEN THOR N & JUDY V RR 1 SITE 7 COMP 6 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19730806	20030131
"	"	Falls Creek	Irrigation	3.08	AF	T	N	FRANSEN THOR N & JUDY V RR 1 SITE 7 COMP 6 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19730806	20030131
C119687	5301B S6 (PD28266)	Falls Creek	Irrigation	3.66	AF	T	N	BARABONOFF CLARENCE & STEVE & PAUL C/O PO BOX 309 ROBSON BC V0G1X0	NEL - SLOCAN JUNCTION	Awaiting Sign	N/A	19940709	0
C119688	5301B S6 (PD28266)	Falls Creek	Irrigation	3.66	AF	T	N	BARABONOFF CLARENCE & STEVE & PAUL C/O PO BOX 309 ROBSON BC V0G1X0	NEL - SLOCAN JUNCTION	Awaiting Sign	N/A	19940709	0
C119689	5301B S6 (PD28266)	Falls Creek	Irrigation	3.66	AF	T	N	BARABONOFF CLARENCE & STEVE & PAUL C/O PO BOX 309 ROBSON BC V0G1X0	NEL - SLOCAN JUNCTION	Awaiting Sign	N/A	19940709	0
								BARABONOFF CLARENCE &					

C119690	5301B S6 (PD28266)	Falls Creek	Irrigation	3.66	AF	T	N	STEVE & PAUL C/O PO BOX 309 ROBSON BC V0G1X0	NEL - SLOCAN JUNCTION	Awaiting Sign	N/A	19940709	0

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Licence No	WR Map/ Point Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C048653	5301B Z5 (PD28310)	Garrity Creek	Irrigation	4	AF	T	N	JENSTAD RONALD J SITE 6 COMP 17 RR 1 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19760414	0
C059963	5301B Q (PD28315)	Garrity Creek	Domestic	500	GD	T	N	BRENNEN MICHAEL & BEVERLEY BOX 973 NELSON BC V1L6A5	NEL - SLOCAN JUNCTION	Current	N/A	19820727	0
C062513	5301B P6 (PD28311)	Garrity Creek	Domestic	500	GD	T	N	ERSKINE LESLIE J & GAYLE I 819 GORDON RD NELSON BC V1L3L8	NEL - SLOCAN JUNCTION	Current	N/A	19830624	0
C062959	5301B Q (PD28315)	Garrity Creek	Domestic	500	GD	T	N	HANDLY JAMES & CELIA SITE 7 COMP 5 RR 1 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19210820	0
"	"	Garrity Creek	Irrigation	1.33	AF	T	N	HANDLY JAMES & CELIA SITE 7 COMP 5 RR 1 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19210820	0
C063866	5301B Q (PD28315)	Garrity Creek	Domestic	500	GD	T	N	PENNY DESMOND SITE 7 COMP 21 RR 1 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19840504	0
C114323	5301B D7 (PD28314)	Garrity Creek	Domestic	500	GD	T	N	VLAHOVICH ROSE I RR 1 SITE 7 COMP 2 SOUTH SLOCAN BC V0E2G0	NEL - SLOCAN JUNCTION	Current	N/A	19990420	20020325

C114368	5301B D7 (PD28314)	Garrity Creek	Domestic	500	GD	T	N	SHERMAN PATRICK D GENERAL DELIVERY SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19730728	19991215
C114370	5301B D7 (PD28314)	Garrity Creek	Domestic	500	GD	T	N	JOHNSEN OLAV & SUSAN J RR 1 S7 C71 4865 BAINS RD SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19770221	19991215
C120626	5301B P6 (PD28311)	Garrity Creek	Domestic	500	GD	T	N	BOVEN CHRISTIAAN F 1917 EASTERN DR PORT COQUITLAM BC V3C2T7	NEL - SLOCAN JUNCTION	Awaiting Sign	N/A	19781219	0
F062586	5301B Q (PD28315)	Garrity Creek	Domestic	315	GD	T	N	PENNY CHARLES H & TANIS RR 1 COMP 14 SITE 7 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19520708	0
F062587	5301B Q (PD28315)	Garrity Creek	Domestic	200	GD	T	N	PENNY CHARLES H & TANIS RR 1 COMP 14 SITE 7 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19640420	0

Total number of Licences and/or Applications found is **11**

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Licence No	WR Map/ Point Code	Points Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C046657	5301B R4 (PD28286)	PD28286	Arden Spring	Domestic	250	GD	T	N	HUFTY FRANK JAMES RR1 SITE 7 COMP 47 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Pending	Abandonment Pend	19690704	0
"	"	PD28286	Arden Spring	Irrigation	.625	AF	T	N	HUFTY FRANK JAMES RR1 SITE 7 COMP 47 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Pending	Abandonment Pend	19690704	0

Total number of Licences and/or Applications found is **1**

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Licence No	WR Map/ Point Code	Points Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C050477	5301B N5 (PD28283)	PD28283	Bronaugh Creek	Domestic	500	GD	T	N	BRONAUGH JOHN M 712 CARBONATE ST NELSON BC V1L4P8	NEL - SLOCAN JUNCTION	Current	N/A	19760824	0

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Licence No	WR Map/ Point Code	Points Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C053446	5301B N6 (PD28296)	PD28296	Ellis Spring	Domestic	500	GD	T	N	CARRINGTON LEIGH-ANN 408 622 FRONT STREET NELSON BC V1L4B7	NEL - SLOCAN JUNCTION	Current	N/A	19780829	0

Total number of Licences and/or Applications found is **1**

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Licence No	WR Map/ Point Code	Points Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C050476	5301B P5 (PD28284)	PD28284	Hope Spring	Domestic	500	GD	T	N	BRONAUGH JOHN M 712 CARBONATE ST NELSON BC V1L4P8	NEL - SLOCAN JUNCTION	Current	N/A	19760824	0

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Licence No	WR Map/ Point Code	Points Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C046660	5301B S4 (PD28285)	PD28285	Husum Spring	Domestic	250	GD	T	N	HUFTY FRANK JAMES RR1 SITE 7 COMP 47 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Pending	Abandonment Pend	19690704	0
"	"	PD28285	Husum Spring	Irrigation	1.25	AF	T	N	HUFTY FRANK JAMES RR1 SITE 7 COMP 47 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Pending	Abandonment Pend	19690704	0

Total number of Licences and/or Applications found is **1**

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Licence No	WR Map/ Point Code	Points Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C060523	5301B P4 (PD28287)	PD28287	Larch Spring	Domestic	500	GD	T	N	JENSEN KIRK E & COLETTE M RR 1 SITE 7 COMP 13 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19680423	0
"	"	PD28287	Larch Spring	Irrigation	1.25	AF	T	N	JENSEN KIRK E & COLETTE M RR 1 SITE 7 COMP 13 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19680423	0

Total number of Licences and/or Applications found is **1**

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Licence No	WR Map/ Point Code	Points Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C059379	5301B T6 (PD28282)	PD28282	Pauline Spring	Domestic	500	GD	T	N	ANDISON JAMES & TAMMIE C L 4501 BAINES RD SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19791009	0
"	"	PD28282	Pauline Spring	Irrigation	1.25	AF	T	N	ANDISON JAMES & TAMMIE C L 4501 BAINES RD SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	19791009	0

Total number of Licences and/or Applications found is **1**

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Licence No	WR Map/ Point Code	Points Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C116254	5301B A8 (PD76061)	PD76061	Picton Spring	Domestic	500	GD	T	N	BRONAUGH J MITCHELL ET AL RR 1 SITE 7 COMP 15 SOUTH SLOCAN BC V0G2G0	NEL - SLOCAN JUNCTION	Current	N/A	20010530	20010801

Total number of Licences and/or Applications found is **1**

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APPENDIX B

Equivalent Clearcut Area Tables

Garrity Creek ECA Calculations - (July 2005)

Openings (Existing Only)

Mapsheet	Opening	H60 Line	Proj. Age	Status	Area (Ha)	Tree Height (m)	% Recovery	ECA Above (ha)	ECA Below (ha)
082F043	16	above	45	IMM	0.6	4.8	25.0	0.5	0.0
082F043	16	below	45	IMM	5.6	4.8	25.0	0.0	4.2
082F043	62	below	7	IMM	11.5	1.0	0.0	0.0	11.5
082F043	63	above	4	NSR	3.0	0.7	0.0	3.0	0.0
082F043	63	above	4	Layer 1	5.7	28.7	90.0	0.6	0.0
082F043	63	above	4	Layer 2	3.5	16.5	90.0	0.4	0.0
082F043	63	above	4	Layer 3	8.3	8.8	75.0	2.1	0.0
082F043	63	above	4	Layer 4	2.8	1.2	0.0	2.8	0.0
082F053	14	above	19	IMM	22.2	7.5	75.0	5.6	0.0
082F053	14	below	19	IMM	2.9	7.5	75.0	0.0	0.7
082F053	15	above	48	IMM	2.3	10.0	90.0	0.2	0.0
082F053	19	above	18	IMM	1.4	6.1	50.0	0.7	0.0
082F053	19	below	18	IMM	1.9	6.1	50.0	0.0	1.0
082F053	20	above	16	IMM	2.2	5.3	50.0	1.1	0.0
082F053	20	below	16	IMM	10.8	5.3	50.0	0.0	5.4
082F053	26	above	15	IMM	7.7	3.8	25.0	5.8	0.0
082F053	27	above	14	IMM	8.5	4.2	25.0	6.4	0.0
082F053	30	above	16	IMM	5.0	4.7	25.0	3.8	0.0
ROADS		above			1.8		0.0	1.8	0.0
ROADS		below			4.0		0.0	0.0	4.0
TRAILS		above			0.5		0.0	0.5	0.0
TRAILS		below			0.0		0.0	0.0	0.0
Sub-basin Area =		**393.0 ha**					**Totals**	**35.0**	**26.8**
							Total ECA		**61.8**
							% ECA		**15.7**
							% Weighted ECA		**20.2**

Proposed Blocks and Roads

082F043	15-55	below			4.2		0.0	0.0	4.2
082F043	15-71	above			2.0		0.0	2.0	0.0
082F053	15-53	above			2.7		0.0	2.7	0.0
ROADS		above			0.0		0.0	0.0	0.0
ROADS		below			0.0		0.0	0.0	0.0
Sub-basin Area =		**393.0 ha**					**Totals**	**4.7**	**4.2**
							Total ECA		**8.9**
							% ECA		**2.3**
							% Weighted ECA		**2.9**

Total ECA Post-Harvest

Sub-basin Area =	**393.0 ha**	**Totals**	**39.7**	**31.0**
		Total ECA		**70.7**
		% ECA		**18.0**
		% Weighted ECA		**23.0**

ROADS treated as linear openings 10 metres in width, resulting in 1.0 ha/km ECA (no recovery)
TRAILS treated as linear openings 5 metres in width, resulting in 0.5 ha/km ECA (no recovery)

APPENDIX C

Selected Photographs

Photo A (0372) - Fractured bedrock outcrop in proposed Block 15-71.

Photo B (3497) - Cutslope failure and sediment in ditchline on Garrity FSR (GPS 507).

Photo C (3516) - Seepage flowing onto old road on Bronaugh property (GPS 522)..

Photo D (3517) - Seepage flowing along old road on Bronaugh property (GPS 523).

Photo E (3457) - Falls Creek outlet into Kootenay Lake through railway culverts (GPS 500).

Photo F (3458) - Pond formed by railway at outlet into Kootenay Lake (GPS 500). Note absence of sediment.

Photo G (3467) - Highway 3A culvert inlet on Falls Creek (GPS 501).

Photo H (3530) - View upstream from weir at community intake site. Intake is set in gravel deposit (GPS 532).

Photo I (3533) - Control structure at community intake site(GPS 532).

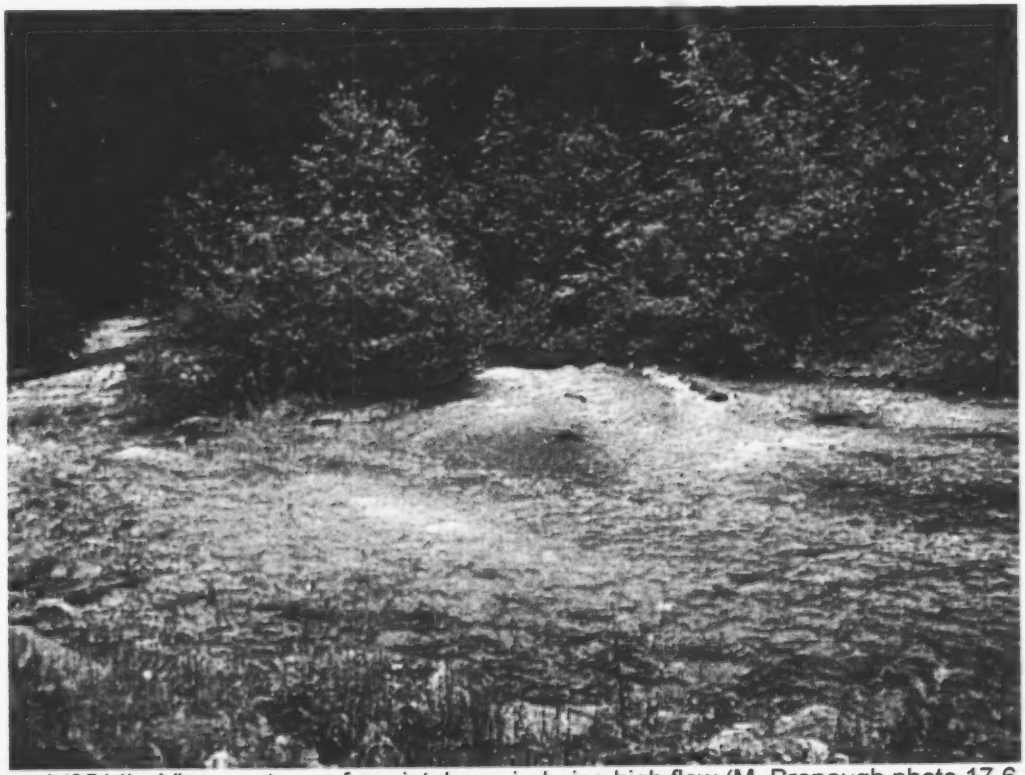


Photo J (0514) - View upstream from intake weir during high flow (M. Bronaugh photo 17-6-2005).

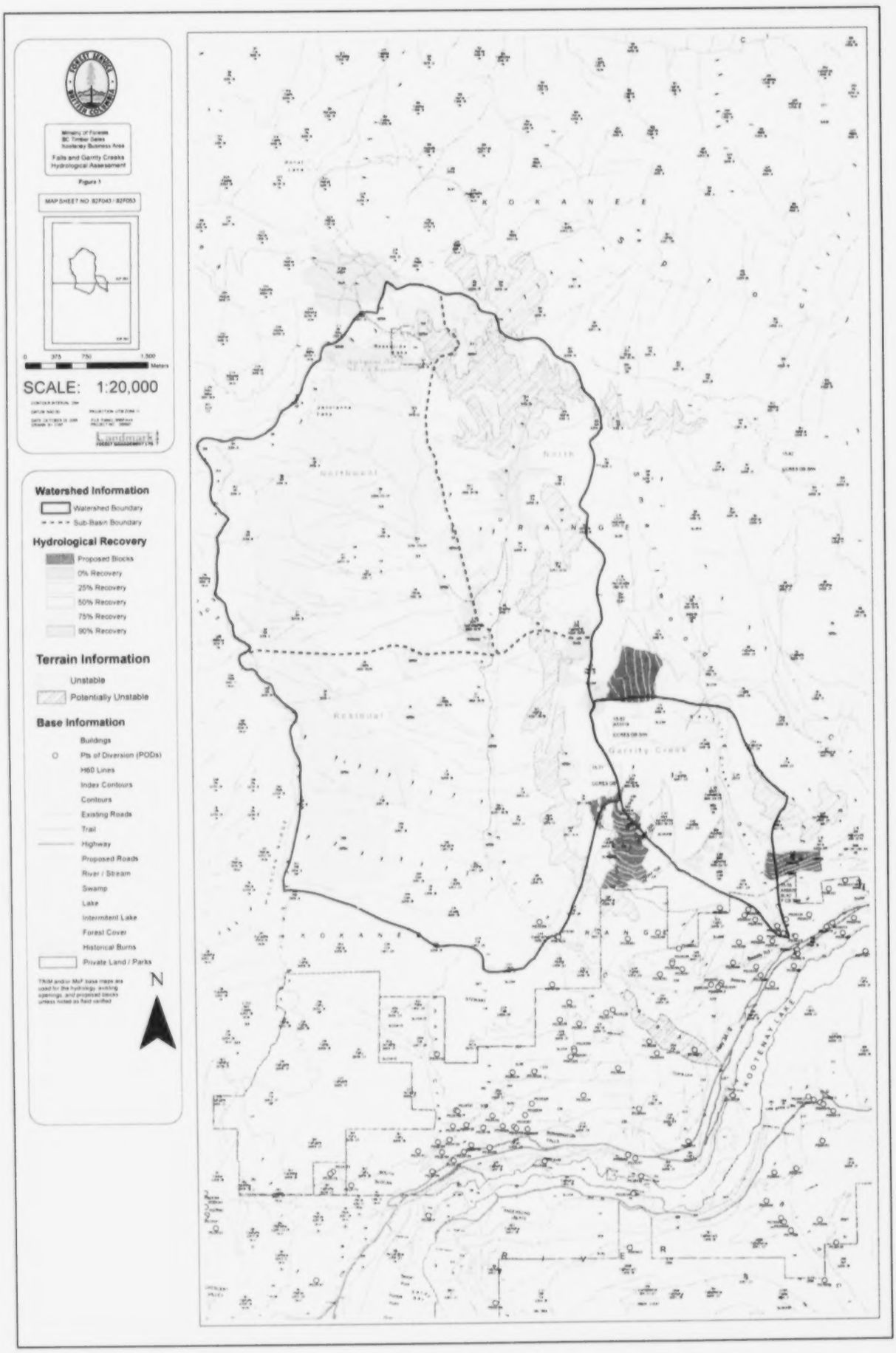
Photo K (0511) - Discouloured water at community intake site during high flow (M. Bronaugh photo 17-6-2005).

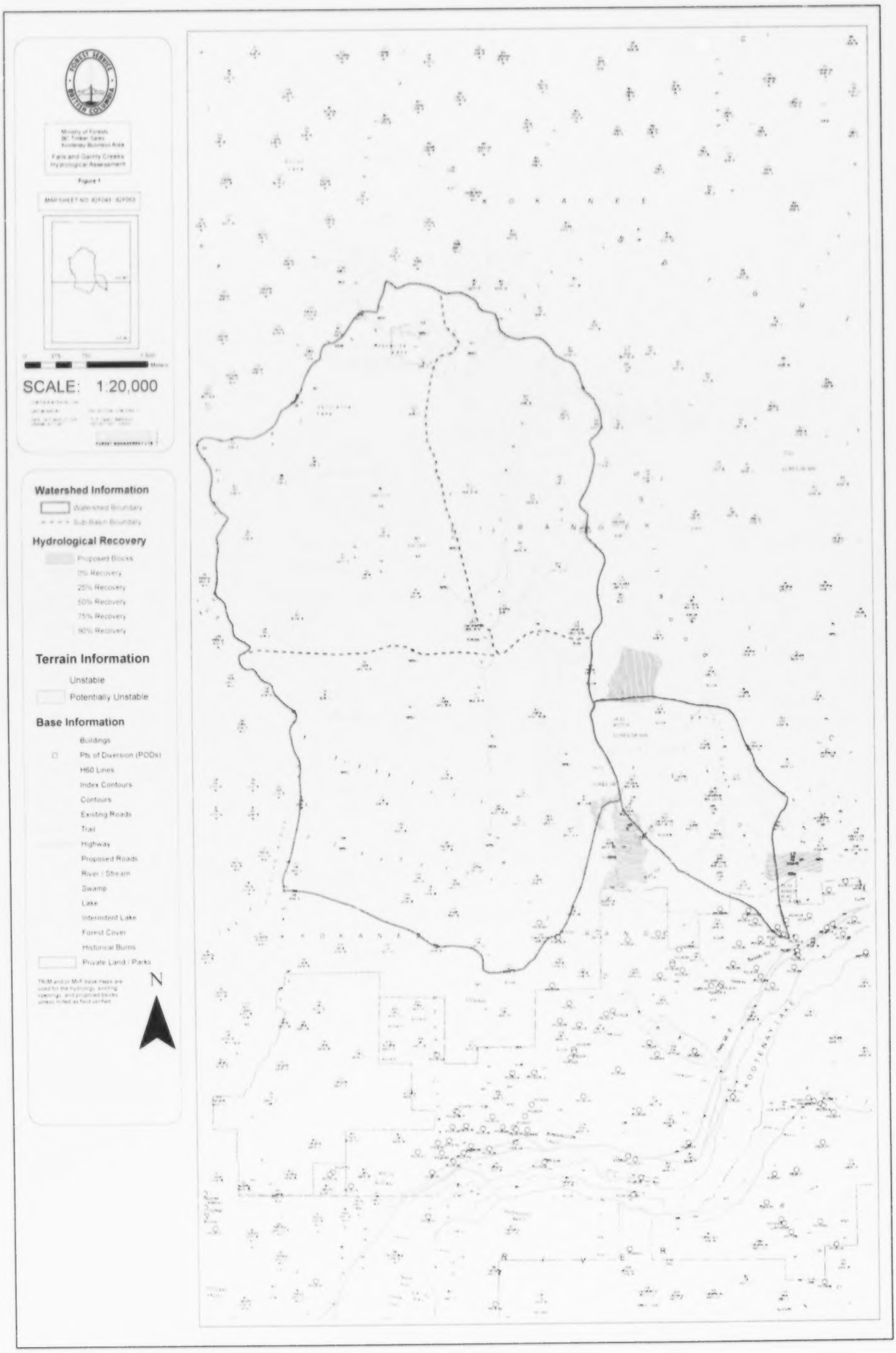
Photo L (3549) - Small channel near intake site coming from east valley wall (GPS540).

Photo M (3473) - Garrity Creek above Beasley Road. Note cobble deposit (GPS 502).

Photo N (3475) - Garrity Creek above Beasley Road. Mossy bedrock and bedload (GPS 502).

Photo O (3487) - Garrity Creek above FSR crossing (GPS 503).


Ministry of Forests
BC Timber Sales
Kootenay Business Area
Falls and Garrity Creeks
Hydrological Assessment
Figure 1
MAP SHEET NO: 82F043 / 82F053
0 375 750 1,500
Meters
SCALE: 1:20,000
Landmark
Watershed Information
Watershed Boundary
Sub-Basin Boundary
Hydrological Recovery
Proposed Blocks
0% Recovery
25% Recovery
50% Recovery
75% Recovery
90% Recovery
Terrain Information
Unstable
Potentially Unstable
Base Information
Buildings
Pts of Diversion (PODs)
H60 Lines
Index Contours
Contours
Existing Roads
Trail
Highway
Proposed Roads
River / Stream
Swamp
Lake
Intermitent Lake
Forest Cover
Historical Burns
Private Land / Parks
TRIM and/or MoF base maps are used for the hydrology, existing openings, and proposed blocks unless noted as field verified
N
K O X A N E
R A N G E
Garrity Creek
KOOTENAY LAKE

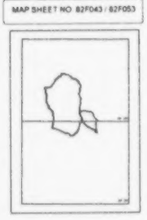

Ministry of Forests
BC Timber Sales
Kootenay Business Area
Falls and Gormly Creeks
Hydrological Assessment
Figure 1
MAP SHEET NO: 82F/043 - 82F/053
SCALE: 1:20,000
Watershed Information
Watershed Boundary
Sub-Basin Boundary
Hydrological Recovery
Proposed Blocks
0% Recovery
25% Recovery
50% Recovery
75% Recovery
90% Recovery
Terrain Information
Unstable
Potentially Unstable
Base Information
Buildings
Pts of Diversion (PODs)
H60 Lines
Index Contours
Contours
Existing Roads
Trail
Highway
Proposed Roads
River / Stream
Swamp
Lake
Intermittent Lake
Forest Cover
Historical Burns
Private Land / Parks
TRIM and/or MoF base maps are used for the hydrology, existing openings, and proposed blocks unless noted as field verified.
N

Ministry of Forests
BC Timber Sales
Kootenay Business Area

Falls and Garrity Creeks
Hydrological Assessment

Figure 3

MAP SHEET NO. 82F043 / 82F053



SCALE: 1:10,000

CONTOUR INTERVAL: 20M

DATUM: NAD 83 PROJECTION: UTM ZONE 11

DATE: JULY 1, 2005 FILE TARGET: 82F043.mxd
REVISED: 07/11/07 PROJECT NO: 05007

Landmark FOREST MANAGEMENT LTD.

Watershed Information

- Watershed Boundary
- Sub-Basin Boundary

Hydrological Recovery

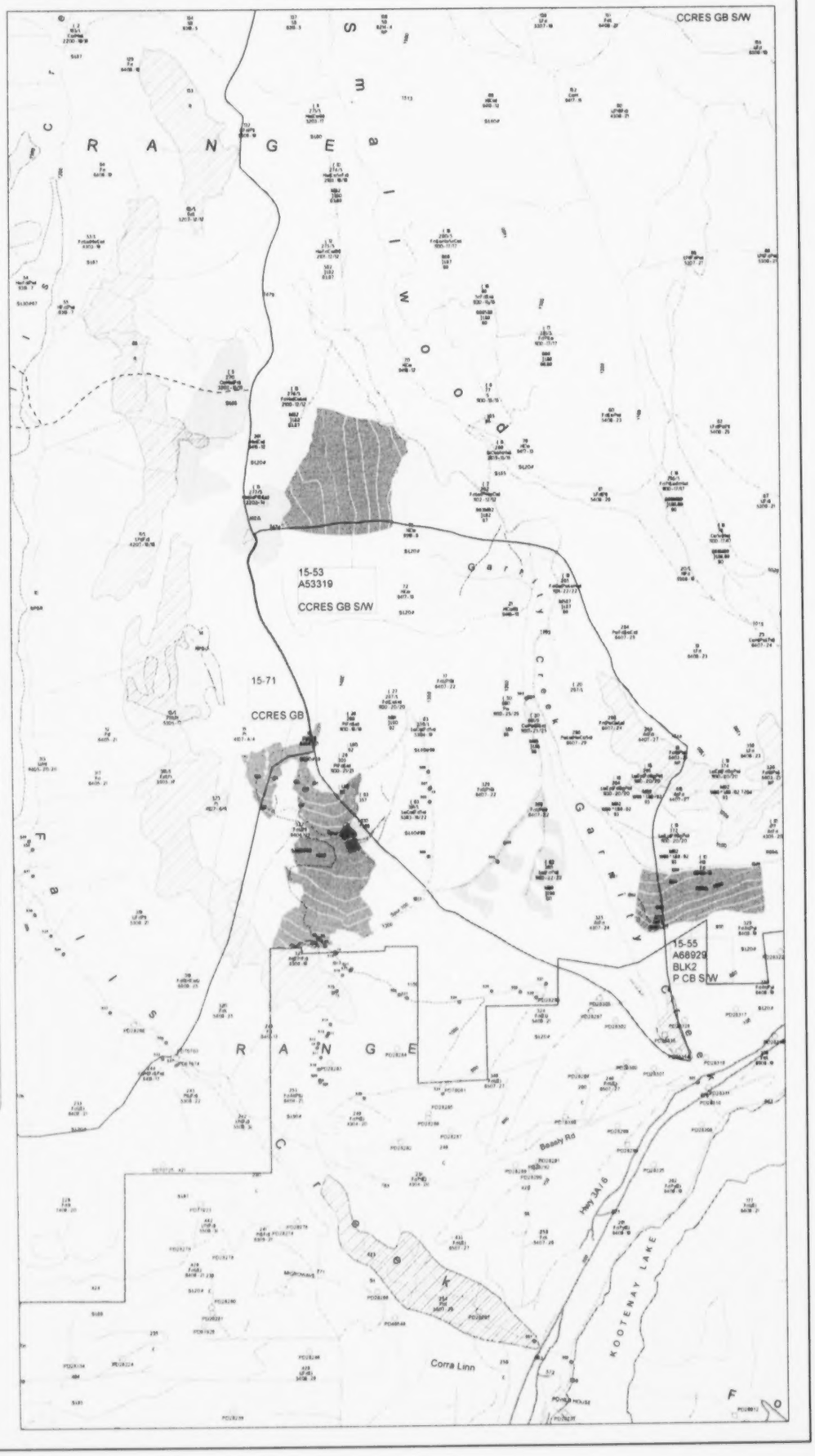
- Proposed Blocks
- 0% Recovery
- 25% Recovery
- 50% Recovery
- 75% Recovery
- 90% Recovery

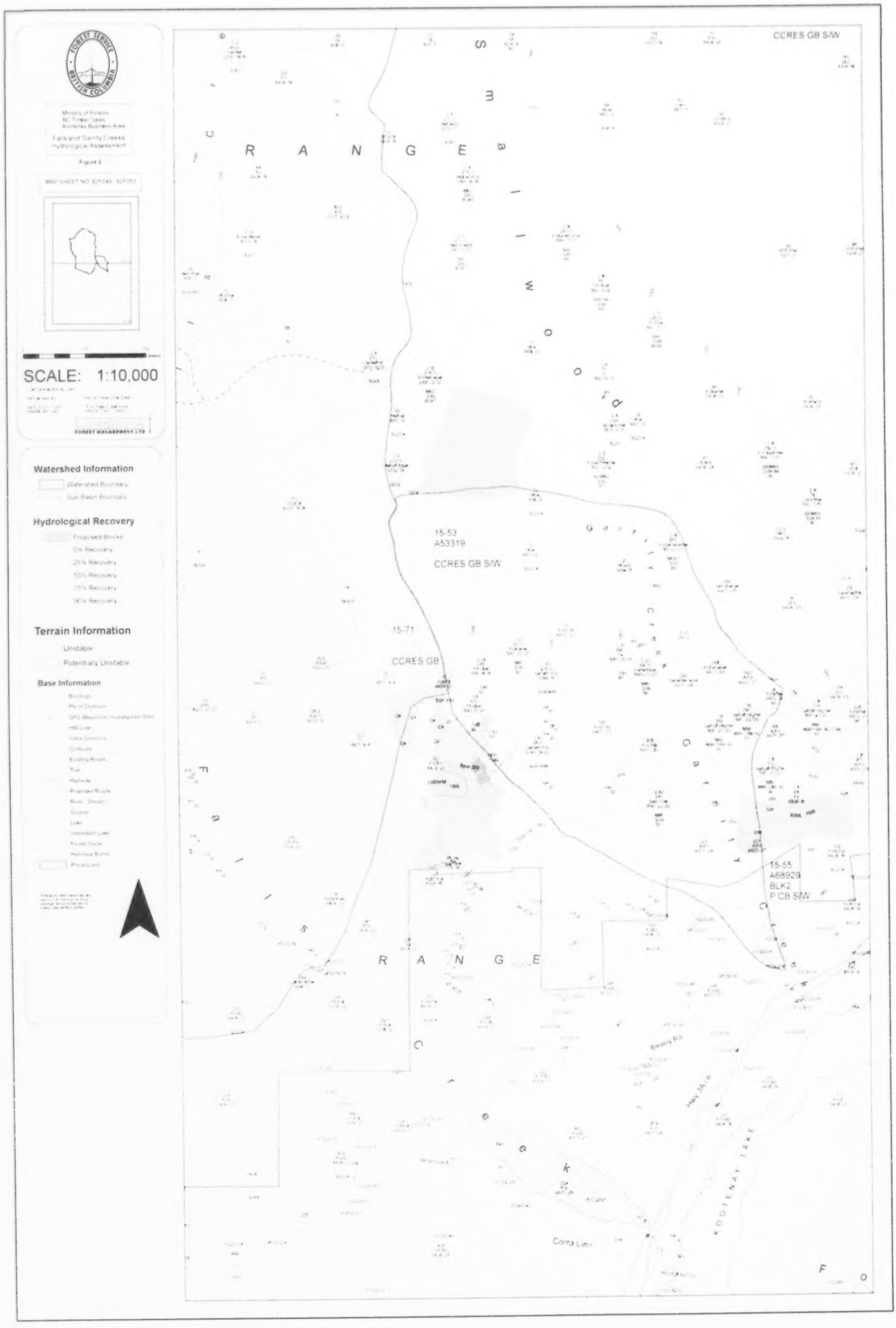
Terrain Information

- Unstable
- Potentially Unstable

Base Information

- Buildings
- Pits of Diversion
- GPS Waypoints (Investigation Site)
- H60 Line
- Index Contours
- Contours
- Existing Roads
- Trail
- Highway
- Proposed Roads
- River / Stream
- Swamp
- Lake
- Intermittent Lake
- Forest Cover
- Historical Burns
- PrivateLand




Ministry of Forests
BC Timber Sales
Kootenay Business Area
Falls and Garrity Creeks
Hydrological Assessment
Figure 2
SCALE: 1:10,000
FOREST MANAGEMENT LTD.
Watershed Information
Watershed Boundary
Sub-Basin Boundary
Hydrological Recovery
Proposed Blocks
0% Recovery
25% Recovery
50% Recovery
75% Recovery
90+ Recovery
Terrain Information
Unstable
Potentially Unstable
Base Information
Buildings
Pits of Diversion
GPS Waypoints (Invalidation Site)
Index Contours
Contours
Existing Roads
Trail
Highway
Proposed Roads
River / Stream
Swamp
Lake
Intermittent Lake
Forest Cover
Historical Burns
Private Land
CCRES GB S/W
15-53
A53319
CCRES GB S/W
15-71
CCRES GB
15-55
A68929
BLK2
P CB S/W
Rsw 200
Garrity Creek
Falls Creek
Corra Linn
KOOTENAY LAKE
Hwy 3A
RANGE
RANGE